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Some Notes on Anomalies in the Domestic Cat

Chauncey McLean Gilbert, Howard F. Parkes, and John R. Gregory

Any one who has had any considerable experience in the dissection of vertebrate material, is aware that vascular abnormalities are not uncommon in individuals of all vertebrate classes. However, from what experience the senior author has had in the field of vertebrate anatomy, he is of the opinion that vascular abnormalities are most common in urodele amphibians and mammals—in the first, because of their neotonic condition; in the latter, because of their longer phylogenetic history. Again, he believes, it may be taken as a rule, that the pattern of the arterial system is more constant than that of the venous, although many anomalies occur, especially those relating to the derivatives of the aortic arches.

Of the venous vessels of the mammals the most variable is the postcava and its tributaries. This variability is, of course, due to the large number of embryonic blood channels which enter into the definitive postcava. For instance, the senior author has observed a number of instances of a double postcava, due to the persistence of the postcardinal veins caudad to the subcardial anastomosis, and a degeneration of the supracardinal veins. This anomaly was first reported for the cat by Metcalf and Metcalf (1918). Many variations relative to renal, spermatic and ovarian veins are also not uncommon. Anomalous conditions of the precaval veins are, however, much less common as its embryonic development is much less complicated than that of the postcava.

Persistence of Left Superior Vena Cava

Six years ago, what appears to be an unusual anomaly, at any rate in the cat, was brought to the attention of the senior author by one of his students in comparative anatomy. In this cat, the left anterior cardinal vein, together with that portion of the duct of Cuvier which did not contribute to the coronary sinus, had persisted, thus joining the left innominate with the coronary sinus of the heart. The left innominate was of considerably less than normal size, and the persisting left anterior cardinal about one-half the diameter of the precava. This condition is, of course, a retention of a relatively late embryonic condition. It seems strange that this anomaly should not be more

common, but I have found only one record of its occurrence in the cat, that of Grant (1917).

Several years ago, A. Brazier Howell told the senior author that he had seen a single case of a similar anomaly in man. Huffmire and Bower (Anat. Rec., Vol. 17, No. 3, 1919) described and pictured an identical condition in man. They stated that "the persistence of the left superior cava is relatively common in still-born children, but its occurrence in the adult is rare enough to warrant a record of the cases". They furthermore state, that according to McCotter (1916), only ten cases of persistence of the left superior cava have been reported. Strange to say, in the same number of the same journal, Smith described a similar anomaly in man, which differed from the above only in degree, not in kind—the two innominate veins being of apparently equal size and the left duct of Cuvier persisting as a relatively small vein, the extended oblique vein of the left atrium, which is continuous with the left highest intercostal vein. In Smith's anomaly, however, the coronary sinus did not open into the right atrium, all the coronary drainage taking place by way of the highest intercostal vein. Gibson (1921) described an anomaly quite similar to that of Smith, but made no mention of the drainage of the coronary sinus. He, however, states that the condition has been reported some sixty times. He says that McCotter observed it once only among seven hundred dissecting-room subjects.

In spite of the fact that the persistence of the left precava in man has been reported so many times, it is probably relatively uncommon. It may, however, be more common in man than in the cat, as the left highest intercostal vein of man is, in part, a remnant of the embryonic left anterior cardinal, so that a persistence of the distal portion of the left duct of Cuvier —the proximal portion being represented by the oblique vein of the left atrium—would result in the retention of the embryonic condition.

An Anomalous Condition of the Precava

An unusual anomalous condition of the precava of the cat was observed in a cat which was dissected during the current Summer Session (Fig. 1). In this animal the left innominate (*8*) appears as a prolongation of the precava (*1*). The left innominate is formed by the common junction of the right and left external jugular veins (*19, 20*) and the left subclavian vein (*9*). The left transverse scapular vein (*15*) is in its normal location as a branch of the left external jugular vein, but there is no transverse scapular vein entering the right external jugular. The right innominate vein (*6*) passes out of the thoracic cavity in its normal position, just anterior to the first rib, while the left costocervical vein (*5*), which, incidentally, is unusually large

occupies the same relative position on the left side. The right innominate vein is much smaller than the left, as it does not receive the blood from the right external jugular, while the left innominate receives blood from both right and left external jugulars.

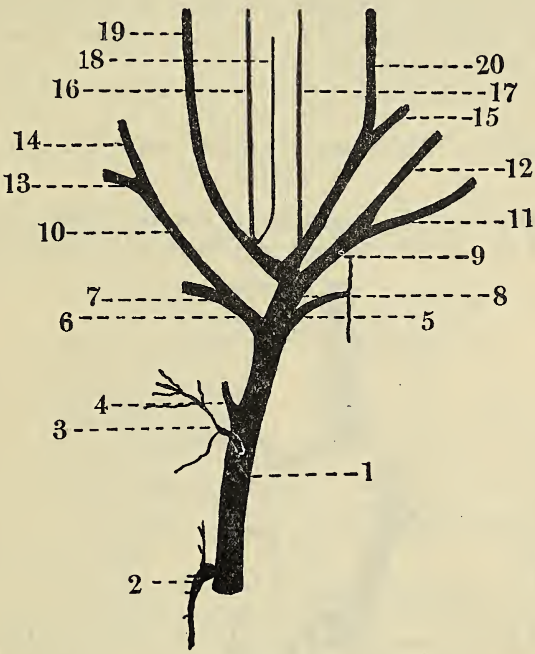

FIGURE 1.

Anomalous condition of precava of cat. *1*, postcava; *2*, azygos; *3*, internal mammary; *4*, vertebral; *5*, costocervical; *6*, right innominate; *7*, right subclavian; *8*, left innominate; *9*, left subclavian; *10*, right subscapular; *11*, left auxiliary; *12*, left subscapular; *13*, continuation of right subscapulas; *14*, right transverse scapular; *15*, left transverse scapular; *16*, right internal jugular; *17*, left internal jugular; *18*, inferior thyroid; *19*, right external jugular; *20*, left external jugular.

Unfortunately the identity of the branches of the right innominate were not determined without peradventure, as these vessels had been cut off by the student, who dissected the animal, at the points shown on the figure, and the distal portions of the veins had been removed. The branches of the left innominate were, however, intact and were identified without question.

It would seem, however, that the vessel (*7*) must be the right subclavian, the vessel (*10, 13*) the right subscapular, and the vessel (*14*) the right transverse scapular, which compensates for the want of this vein as a branch of the right external jugular. The vein (*10*) and its branches (*13, 14*) were, how-

ever, completely detached from the surrounding muscles, so even their exact position could not be determined.

The peculiar asymmetry of the precava and its tributaries must have been initiated at a relatively early embryonic stage and, in all probability, the right external jugular vein never entered the right anterior cardinal at any stage of development. Because of the almost upright position of the left innominate, its tributaries were received at a much higher level than those of the right innominate.

We have been unable to find any record of this type of anomaly.

A Connection Between Phrenic and Gastrosplenic Veins

Occasionally, when dissecting a doubly injected cat, it will be found that the portal system is also completely injected. This,

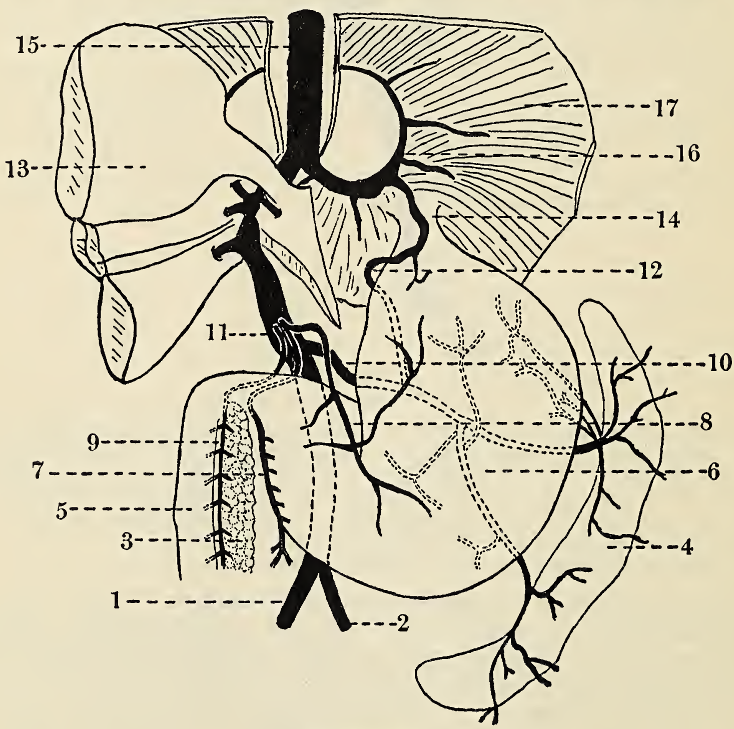

Figure 2.

Sketch showing anastomosis between gastrosplenic and phrenic veins of cat. *1*, superior mesenteric; *2*, inferior mesenteric; *3*, pancreas; *4*, spleen; *5*, duodenum; *6*, stomach; *7*, gastroepiploica; *8*, coronaria ventriculi; *9*, pancreatico-duodenalis; *10*, gastrosplenic; *11*, portal; *12*, vein connecting gastrosplenic with phrenic, which also receives blood from cardiac end of stomach; *13*, liver; *14*, oesophagus; *15*, postcava; *16*, phrenic; *17*, diaphragm.

of course, indicates that there is a connection between the portal and systemic circulations.

This anomaly, which has been observed a number of times by us, has always consisted (see Fig. 2) of an anastomosis (*14*) between the phrenic vein (*16*) and the gastrosplenic (*10*).

Inez Whipple Wilder (1919) described a somewhat similar condition in a male cat, with the exception that there was a strong anastomosis between the phrenic and coronary veins and a further connection between this anastomosis and the gastrosplenic vein. Wilder found a decided hypertrophy of the kidneys of the cat, which she attributed to added work put upon them by the diversion of a large portion of the portal blood from the liver directly into the systemic circulation. In the cats, possessing this anomaly which we have observed, the kidneys were not noticeably larger than normal. This probably was due to the fact that in the cases observed by us the anastomosis was not as extensive as that observed by Wilder.

Complete Absence of Left Kidney

However, in the male cat from which Fig. 1 was drawn, the left kidney was entirely absent. The left renal vein and artery were missing, but the left adrenal gland and testis were present. There was no sign of the left ureter, nor did we find any trace of the left vas deferens in the abdominal cavity. The latter is not surprising as there was no ureter for it to loop around and hold it within the cavity.

Hunt (1918) described a similar condition in a male cat, only, in this case, it was the right kidney which was missing. He, however, found a section of the right ureter, about 1.5 cm. long attached to the bladder in the normal manner. Hunt said nothing about the vas deferens, but mentioned that the right testis was well-developed.

Unfortunately, in our case, the presence or absence of the left vas deferens was never actually demonstrated, as the student to whom the dissection was entrusted did a very bad job, due, in part, to the fact that he allowed the parts to become badly dried out. It is possible that the vas deferens had slipped through the inguinal canal at the time of the descent of the testis.

Radasch (1908) mentioned and pictured a case of the absence of right kidney and ureter and right genital tract in a female cat. The narrow vagina opened into a left uterus only. He was not able to say whether both ovaries were present, as the student who brought him the specimen had not noted these structures.

Radasch (1908), who made an extensive review of the literature relative to the absence of a kidney in man and other mammals, says that instances have been mentioned by Aristotle,

Vesalius (1543), Lopez (1564), Columbus (1572), Bauhinus (1621), Laurentius (1628), Duretus (1635), Riolanus (1648), and Eustachius (1707). He adds, however, that these references are quite uncertain, "as no distinction had been drawn between atrophied, fused, and undeveloped kidneys".

He says that Mosler (1863) tabulated 14 cases of absence of the kidney; in 7 of these the ureter had failed to develop, while in 2 the kidney was but rudimentary. The senior author has observed a case of a very small kidney in a cat. The kidney, about 2 cm. in length, was embedded, sectioned, and stained. It appeared to be entirely normal in structure, and was undoubtedly functional. Such a case could hardly be included among cases of absence of a kidney.

As to the frequency of this anomaly in man, Radasch mentions 12 cases among 18,423 autopsies. He also states that it has been found in the horse, steer, sheep, dog, rabbit, pig, and hen, and that Prettner found at the abattoir two cases in pigs and one in a steer among 15,000 animals slaughtered.

Radasch found records of about 255 cases of absence of the kidney in man, of which 100 showed decided defects of the genitalia, over one-half of which occurred in males. He said the parts affected were as follows: "The vas practically absent in 22, the vesicles in 20, the ejaculatory duct in only 9, and the testicles in 15. In the female we find the uterus entirely absent or bicornate in 12, the vagina absent or reduced one-half in only 5, and the oviducts missing in 9, while the ovary was absent in but 4." He also mentions that in a study of 213 cases, Ballowiz found that the left side was more commonly affected than the right, in the proportion of 117 to 88, with 8 undifferentiated. What he meant by the latter part of the statement is not clear.

Lyon (1917) described a case of the absence of the right kidney in a female human individual. In this case, however, the entire right ureter was present, although its cranial portion was reduced to a fibrous cord which disappeared into a loose mass of fibrous and areolar tissue. The right internal genitalia were absent and the left uterus was reduced. The significance of the mass of connective tissue at the cranial end of the ureter was not discussed by the author. The senior author feels that this condition suggests a possible degeneration of the pelvis and collecting tubules which are derivatives of the ureteric evagination. If this interpretation should be a correct one, the failure of the kidney to develop completely, in this case at least, may have been due to a failure of the nephrogenous tissue of the nephrotome to develop metanephric tubules.

Lyon considered the absence of one kidney in the case which he described as being a hereditary defect, as the maternal grandmother of the subject had been operated on for some abdominal

condition and it was found one kidney was absent. This, of course, could hardly be considered as a proof, as it might be a mere coincidence, but it certainly appears to be significant.

Radasch was interested in the cause of absence of the kidney and he postulates that it may be due to the following causes: "(1) Failure of the metanephric evagination, even though the mesonephric duct and body be perfect; (2) appearance and early retrogression of the metanephric evagination; (3) failure of the pronephros, and therefore the mesonephros, to appear."

"In the first instance," he says, "the absence of the kidney in the male would naturally be attended by few if any genital defects, and these would be coincidental and not sequential. In the second instance the resultant condition would be the same. In the third all such cases would be attended by absence of kidney, ureter, efferent ductular system of the testicle, vas, and vesicle on the affected side. From the irregularity of the occurrence of the genital defects, the absence of the kidney seems to be due entirely to the first or second cause; the genital defects then occur secondarily, and not as a direct result of absence of the kidney; that is, they are merely coincidental. Another reason for taking this view is the fact that in most of the cases of absent kidney the ureter and vessels also were absent or rudimentary, pointing more to the first or second cause."

"In the female in the first or second cause there would be no genital defects, whether we assume that the Muellarian ducts are derived from the mesonephric duct or independent; such defects would then be merely coincidental. In the third cause, if the Muellarian ducts were derived from the mesonephros partially or entirely, then as a result of its absence the entire internal genitals should be practically absent. In fact, that has not occurred in any case. In fact the uterus was absent or bicornate in but one-third of the cases. The facts as found in the adult body seem to indicate that the Muellarian ducts have an independent origin and are not derived from the mesonephric duct by segmentation, at least not in the higher vertebrates."

The senior author agrees with Radasch in eliminating the third cause as a possibility, if for no other reason that the failure of the mesonephros to develop would result in an anomalous condition of the postcava due to the want of the embryonic sub- and supracardinal veins on the side where the defect occurred.

According to Radasch's own figures, about 39.2 per cent of the cases of absent kidney also show decided defects of the internal genitals. This percentage seems to be too high to be merely coincidental. Even if it should be a secondary condition, there must be some causal relationship between the absence of kidney and defects of the internal genitals. Such relationships might be ascribed to insufficient blood supply during embryonic development or to inductive relationships, similar to the relationship between the presence of the optic vesicle and the formation of the lens. There, however, seems to be no good reason for postulating an insufficient blood supply in the 39.2

per cent of the cases and a sufficient supply in 61.8 per cent. As far as the presence or absence of the kidney is concerned, it is entirely possible that the development of metanephric tubules is dependent on the presence of the metanephric evagination of the mesonephric duct. In Lyon's anomaly, and in several others mentioned by Radasch, the ureter was described as entire. In these cases, therefore, the defect may have been situated in the nephrogenous tissue. As far as the genital system of the male is concerned, it seems hard to conceive how the absence of the metanephric structures would have any affect in suppressing the mesonephric derivatives which antedated them.

According to Radasch's figures the absence of a kidney occurs about once in every 1,535 human individuals and about once in every 5,000 domestic animals. The history of Lyon's anomaly indicates that the defect may be hereditary. Unfortunately, it is almost impossible to determine the mode of inheritance of internal defects, especially in the case of a defect which is so relatively infrequent, as such defects do not readily lend themselves to genetical experimentation. However, the senior author feels that the congenital absence of kidney, coupled as it is with a decided tendency for genital defects, is not a sporadic occurrence depending on environmental conditions, but a hereditary defect, depending on the genic constitution of the individual.

The senior author finds that anomalies are objects of great interest to his students. When it is possible to explain them in terms of embryology, comparative anatomy, or even genetics, their interest can be used profitably in extending their knowledge of these subjects.

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Aster pilosus Willd. and the var. demotus Blake in the Bull Run Area

H. A. Allard

Aster pilosus Willd. and the more glabrous var. *demotus* Blake are very abundant plants in the vegetation of old fields and pastures throughout the Bull Run area. The var. *platyphyllus* (T. & G.) Blake appears to be less common in this area.

Although the chief distinguishing characters of *A. pilosus* and the var. *demotus* appear to be based upon the presence or absence of dense pubescence on the stems, it is interesting to note that in the Bull Run area, at least, certain differences in growth behavior distinguish them as they intermingle in the fields.

The typical form *A. pilosus* closely intermingles with the var. *demotus* over large areas throughout the Bull Run region. The var. *demotus*, here, flowers some weeks earlier than the species, and on account of lesser stature occupies a distinctly lower stratum in the vegetation of old fields where it abounds. In 1941, *demotus* was in full flower September 14 and had probably begun to flower during the first week of September. At this time *A. pilosus*, almost equally abundant in the same area, had produced much taller, more vigorous plants, so that their overtopping branches occupied a distinct stratum above the var. *demotus* everywhere over the field.

On September 14, none of these taller plants had flowered, and open florets did not appear until September 21. At this time only a few plants had initiated flowering, the majority being without open florets. This would indicate that the species and its var. *demotus* differ not only with respect to the morphological character of presence of pubescence, but also with respect to time of flowering and habit of growth under the same habitat conditions. Practically all the fall-flowering wild asters of the Washington region require shortening days before flowering is induced. The fact that they flower in autumn is an indication of such relationship to length of day.

The length-of-day requirements of a number of wild asters of the Washington region have been studied, among these being *Aster pilosus* var. *demotus*.[1] This var. is a typical short-day plant, in the tests flowering near mid-September in response to the full length of day. The typical form of *Aster pilosus* appears to have a somewhat lower critical length-of-day requirement for the initiation of flowering, as indicated by its habit of flowering in the Bull Run area a few weeks later than the var. *demotus*. This slight difference in its critical length-of-day response, amounting perhaps to only ½ hour or less is sufficient to account for the increase in height of the plants as observed in the field.

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[1]Tech. Bull. 727, U. S. Dept. of Agric., 1940. (See pp. 30, 31, 32.)

The critical length of day which induces flowering in *pilosus* appears to be near 13½ hours, a length of day which near Washington, D. C., latitude 39°, ends about August 21 as a result of the normal seasonal shortening. After this date the continued shortening of the days would accelerate the reproductive development of this aster.

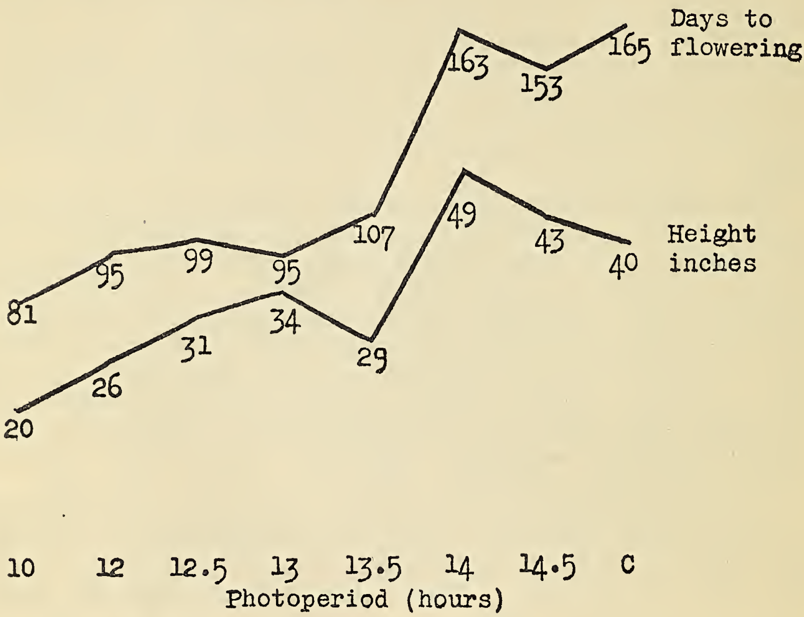

FIGURE 1.

Response of *Aster pilosus*, var. *demotus*, to different constant lengths of day, and days required from the beginning of the tests to opening of flowers, and height in inches when flowering took place. C indicates control which experienced the full length of day. All lengths of day of 13½ hours or less appear to be below the critical for flowering, whereas the photoperiods of 14 hours or longer, as well as the full length of day, greatly delayed flowering, as these were above the critical for a long period. Note the jump from 107 days to 163 days with lengths of day of 13½ hours and 14 hours, relatively a difference of only ½ hour. For the same photoperiods, there has been an increase in height from 29 inches to 49 inches.

Tests have shown (l. c., p. 31, fig. 14) that a constant length of day of 13½ hours induced flowering on July 21. An increase of only ½ hour, making the length of day one of 14 hours daily, delayed flowering until September 15, increasing the period intervening between the beginning of the tests and flowering from 107 days to 163 days, respectively. This slight change in constant length of day also resulted in a height increase from 29 inches for the 13½-hour day to 49 inches for the 14-hour day at the time of anthesis.

The habit of flowering somewhat later than *demotus* would indicate that typical *pilosus* has a slightly lower critical length of day which will initiate flowering, amounting to a difference of ½ hour or less. This slight difference in seasonal response to length of day would be sufficient not only to delay flowering a few weeks, but would account for the increase in height which has characterized *pilosus* in the field, where the two forms grow intermingled in the Bull Run area. This delay in the onset of flowering and increase in height in the wild state would not necessarily appear in all parts of the range of the two forms, if a slight difference in critical length of day alone determined the time of flowering.

The range of *Aster pilosus* is given in manuals as extending from Ontario to Florida. If this typical form has a slightly lower critical length of day throughout this area than the var. *demotus*, the onset of flowering of these would tend to approach, or at least to show the smallest divergence, when they are growing in a region where the seasonal length of day was below the critical for both. With increase in latitude northward throughout the range, the onset of flowering would occur at progressively later dates, since the critical length of day for flowering would occur progressively later in the season as the latitude increased northward. If the critical length of day was not longer than 14 hours for *demotus* and not longer than 13½ hours for *pilosus*, these lengths of day would occur between July 11 and July 21 at latitude 31°; between August 1 and August 11 at 39°, the latitude of Washington, D. C.; and between August 11 and August 21 at 45°, the latitude of Nova Scotia. Near the northern limits of the range, low temperatures would finally intervene and still further delay flowering to a point where neither would show the normal difference of behavior in response to length of day which was obvious southward. The factor of frost and cold sensitivity at these high latitudes might finally bring about extinction and account in part for the limits of the northern distribution of this aster and its varieties.

It would appear that under certain habitat conditions favorable to the fullest expression of all the characteristics, certain physiological behaviors as well as morphological features relating to pubescence tend to distinguish *pilosus* from the var. *demotus*. Both categories involve inherent, constitutional differences, although the slightly different seasonal aspects distinguishing the two forms, associated more closely with physiological expression, appear to be less pronounced and stable than the morphological character of pubescence. However, this physiological distinctiveness is quite as genetic in origin and perhaps has greater evolutionary significance in the persistence and range of the species and its forms, than the fact of more or less pubescence of leaf or stem.

WASHINGTON, D. C.

Sedimentary Petrology of Some Atlantic and Gulf Coast Beach Sands[1]

ROBERT O. WILBUR AND JAMES B. SNOBBLE

Some samples of beach sands along the Atlantic and Gulf coasts were obtained from various localities. The purpose of the investigation was to determine what mineralogical differences and similarities existed between the samples and what bearing these had on the source of the sediment.

The samples examined were obtained from Westbrook, Connecticut; Atlantic City, New Jersey; Ocean City, New Jersey; Hampton Roads, Virginia; Virginia Beach, Virginia; Wrightsville Beach, North Carolina; Myrtle Beach, South Carolina; Savannah, Georgia; Jacksonville, Florida; St. Augustine, Florida; Destin, Florida; Panama City, Florida; Santa Rosa Island, Florida; Pensacola Bay, Florida; Mobile Bay, Alabama; and Mon Luis Island, Alabama.

In the laboratory all of the samples were treated in the same manner. They were first sieved through a 20 mesh screen, after which they were washed thoroughly several times, allowing the sands to settle about 30 seconds each time before the water and debris were poured off. Following this, the samples were boiled in hydrochloric acid to remove all carbonates and limonite stains. This removal of limonite prevents any light minerals from being carried down later with the heavy minerals in the Bromoform separation. After boiling for ten minutes, the sample was cooled and washed again to remove all trace of acid and dried on a hot-plate. The sample was then sieved through 58 mesh bolting cloth. The sand that passed through the bolting cloth was quartered and about 7 cc. was put into a separatory funnel of bromoform which had a specific gravity of 2.8. In this the light minerals floated on the surface while the heavy ones sank to the bottom. The latter were then drawn off on filter paper and dried on the hot-plate. The light minerals were drawn off and dried. Following this, slides were heated on an electric plate, Canada balsam put on, and when it reached a tacky state a small amount, each of the heavy and light portions was sprinkled onto the balsam, a cover glass placed on top and the slides allowed to cool. The slides were then ready to be cleaned and labeled and their mineral content determined.

Microscope observation revealed that certain minerals were found to be predominant in each sample of the light minerals. All samples were characterized by a flood of quartz with feldspar being quite common. The heavy mineral samples were all similar in the presence of magnetite and ilmenite ranging from common to flood although in the majority of samples they were abundant.

[1]Presented before the Geology Section of the Virginia Academy of Science, May 2, 1941.

Garnet was quite common in most of the samples from Westbrook, Connecticut, down to Mobile, but was not identified in the samples from Destin, Santa Rosa Island, Pensacola Bay, Florida, and Mon Luis Island, Alabama. Hornblende was present in varying amounts at all localities except at Destin and Pensacola Bay. In like manner zircon was found in all samples except those taken at Westbrook, Connecticut; Panama City, Florida; and Santa Rosa Island. With the exception of Hampton Roads, tourmaline and sillimanite were present in all samples. Kyanite was absent at Westbrook and St. Augustine; however it ranged from rare to common between Atlantic City and Jacksonville and from common to abundant between Destin and Mobile. Tremolite and rutile varied from rare to common and was present in only half the samples from localities scattered along the coast. Staurolite was common at most localities but was absent at Westbrook, Hampton Roads, and Panama City. Epidote was found to be present, although rare, at several localities. Hypersthene was found in a few of the samples from the more northern beaches.

The most striking feature of the petrology of these beach sands is the general similarity of mineral content. Without exception, these samples indicate pre-Cambrian crystalline rocks as the ultimate source of the sediments from Connecticut to Florida. However, since many of the coastal plain sedimentary formations are known to contain all of these minerals, much of the present beach sand doubtless is derived directly from these. Regardless of whether the coastal plain formations occupy a narrow strip of fifty miles, as at Atlantic City, or have a width of two hundred miles as at Jacksonville, and regardless of whether the pre-Cambrian igneous and metamorphic rocks are adjacent to the beach as at Westbrook, Connecticut, or three hundred miles away as at Jacksonville, the mineral content of the Atlantic and Gulf Coast beach sands is surprisingly similar. A more detailed quantitative study and a study of relative degree of roundness of grain might reveal some significant differences.

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Plants at the Edges of Their Ranges

LENA ARTZ

A paper published in 1914[1] based on careful studies made by the author on the flora of the Sugar Grove area in Ohio discusses some interesting facts concerning the behavior of plants at the edges of their ranges.

Since Virginia has much to offer as a basis for similar studies, a brief summary of the paper on the Ohio flora is here given.

It is stated by the author that such studies are of value to plant geographers and that the proper place to make such a study of the geographic movements of plants, some advancing, others retreating, is at the tension zone at the edge of plant ranges. Well known species are used to stress the main points brought out in this paper.

Observation on the relative abundance of a species at the edge of its range leads to the conclusion that in most cases species are abundant at the edges of their ranges. However, the point is not overlooked that a study of species in a broad way rather than in a restricted one shows that most species are bordered by a fringe of outliers at considerable distance from each other.

A study of factors that might be causes of the determination of ranges leads to the belief that the reproductive function is not a factor of importance in this respect. Statistics connected with a study of the relative abundance of plants of different geographical groups, northern and southern, eastern and western, give evidence that plants do not behave differently on different edges of their ranges.

When climate as a factor is considered, doubts are reached concerning the belief once widely held that at the center of its range a plant occurs in all habitats because it is there widely favored by climate, while at its outer limits it is found only where conditions are most favorable. *Rhododendron maximum* L. is one of several plants used to emphasize the error of this belief. This plant grows, in the area studied, high up on cliffs with extreme southern exposure. Its typical habitat is in dense shade in deep forests where it grows in thickets. Hence competition, not climate seems to be an important limiting factor. The importance of competition as a factor in plant behavior is further stressed by using *Aralia spinosa* L. as an example. Said by most manuals to prefer rich, moist soil of lowlands, this plant, when competition is removed, grows in such abundance in the poor soil of hillsides that it becomes a pest. So, in many instances, not climate, but competition seems to be the factor of greater importance.

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[1]Griggs, Robt. F., *Observation on the Behavior of Some Plants at the Edges of Their Ranges.* Bull. Torrey Bot. Club 41:25-49. 1914.

A second factor considered to be of prime importance is the historical factor. An example to illustrate this is *Tsuga canadensis* (L.) Carr.

Probably once wide-ranging in this area it now grows only in the deep canyons of the Ohio region. It has numerous outlying stations far to the west and south. In the latter places it grows on rocks, both sandstone and limestone, not because those spots are favorable, but because competition of the invading hardwoods has driven this *Tsuga* from more favorable habitats.

Briefly, then, a study of plants in the Ohio area indicates, not fixed, but changing conditions, conditions that indicate a continuation of plant movements following the glacial period. The two most important factors concerned with this movement seem to be competition and the historical factor.

Indiana has proved to be an interesting field for a study of plants at the edges of their ranges.[2] Information obtained from a study of seven peat bogs of Indiana, all of which lie within the borders of the late Wisconsin glaciation, gives evidence to show that the southernmost bogs of this state are older than the more northern bogs and that the southernmost bogs had been conquered by broad-leafed forests before white man's coming while the northern ones had not been completely conquered at that time. In these northern bogs old species of boreal forests are still found today.

Pollen from seven bogs was made the basis for study. The evidence from all these bogs showed uniform sequence of forest dominance: *Abies* to *Picea* to *Quercus* or *Quercus-Carya.* In Bacon's swamp, the farthest south, the last step in the sequence is *Quercus-Acer*, the only one to show definite *Quercus-Acer* dominance. Another exception is at Chicott, seventy miles north of Bacon's swamp where the sequence shows *Pinus* dominant instead of *Picea.*

A study of relic species, such as *Thuja, Larix, Pinus strobus,* and herbaceous plants proved of interest. These plants are now found on cliffs or in bogs where habitat is less favorable to forests advancing from the south. It is found also that these relic species do not advance aggressively and that slight changes affecting their habitats wipe them out completely. Hence the conclusion is reached that such northern species as *Cornus rugosa, Pinus strobus, Thuja, Larix, Gaultheria procumbens, Diervilla lonicera,* and others are following a path of extinction similar to that followed by the same genera that became extinct before white man's coming. It is stated that the slow progress of advance and retreat of the boreal forest at its southern border is not unlike its expansion along its northern border in Alaska.

Since Virginia offers a rich field for the study of plants on

[2]Potzger, J. E. and R. C. Freisner, *Plant Migrations in the Southern Limits of Wisconsin Glaciation in Indiana.* Reprint from American Midland Naturalist. Sept. 1939.

or near the edges of their ranges and since data on such plants, sufficient in amount and accurately kept, may prove of scientific value in interpreting climatic changes, it will be interesting to keep such data and to find out whether such plants as *Lycopodium Selago* L., *Lycopodium inundatum* L., *Lycopodium annotinum* L., *Thuja occidentalis* L., *Clintonia borealis* (Ait.) Raf., *Cypripedium hirsutum* Mill., *Potentilla tridentata* Ait., *Cornus circinata* L'Her., *Trientalis americana* (Pers.) Pursh, *Diervilla lonicera* Mill., *Sambucus racemosa* L., and others are advancing, retreating, or holding their own.

ARLINGTON, VA.

A Forest Fire Prevention and Suppression Program for Virginia

Part II

F. C. Pederson,

State Forester of Virginia

Steps to Prevent the Occurrence of Fires

The seasonal occurrence, gravity and causes of forest fire having been fairly well established, the facts are used as a basis for the formulation and application of the State Forest Service's prevention program. Because ninety-nine out of every hundred fires in Virginia are of human origin, the Service has devoted the majority of its efforts and most of the money available for the fire control work to activities directed toward the reduction to a minimum of the number of man-caused fires. The fire prevention program may be said to rest on three structural pillars: 1—analysis of risks; 2—development and application of methods and technique required to minimize each definite risk; 3—reduction of physical dangers.

The district forester and the chief forest warden in each county are expected to confer immediately prior to each fire season to make a detailed study of the fires which occurred in the county the preceding season for the purpose of determining as accurately as possible the degree of the risk in the various sections of the county and with the object of taking such action as is possible to reduce this risk. The following points are carefully analyzed: general location of fires; time of the year of their occurrence; acreage burned and estimated damage; causes of fires; analysis of previous measures used to prevent fires in the section and new prevention measures needed. Effort is made to obtain exact and intimate knowledge of each risk, the customs and motives of local residents and other forest users, and where, when and why the woods are burned.

Having established the risk zones and the prevailing cause of fires within each zone, the next logical step is the development and application of methods and technique required to minimize each definite risk. Here two plans of attack, direct and indirect, are used to prevent forest fires.

The direct line of attack contemplates a systematic establishment of as large an acquaintance as possible by members of the staff and by the chief forest wardens with influential citizens of the State, particularly with families who live in the forest sections. Effort is made to develop that acquaintance through personal contact to the point of mutual friendship and cooperation, and to accumulate essential information concerning the local

people and their interests. Only on such information can an intelligent effort to induce the local residents to support the policies of forest protection be based. The chief forest wardens in particular are urged to cultivate the friendship of people living in or near forest lands for the purpose of building up an anti-fire sentiment which will minimize the danger of fires starting from land-clearing operations, sawmills, burning to improve the pasture, burning to promote the growth of huckleberries or to kill snakes, boll weevils, cattle ticks and other pests, and from campfires, railroad right-of-way clearings, moonshine operations, and incendiarism. By these personal contacts effort is made to broaden the interests of the local people and extend their vision so that they may see the relation between a destructive fire in the Dismal Swamp or in the Blue Ridge Mountains and county, State and national welfare and their own family well-being. The Forest Service, to a small extent, but as far as possible in view of the limited funds available for the purpose, supplements these personal contacts with illustrated lectures and motion pictures, and with leaflets and other printed matter to be delivered personally or by mail to the people whom the chief warden wishes to interest.

The indirect method of approach attempts to build up a general anti-fire sentiment based on appreciation of the value of our forest resources. Advantage is taken of every opportunity to supply the newspapers of the State, particularly the larger daily newspapers, with news items. One hundred and three such newspaper releases were made by the State Forest Service during the calendar year 1940. A promising field of action is work with the school children and teachers. The promise of a forest-minded people lies much more largely in the coming generation of citizens than in the present. Therefore, the Forest Service sends to school teachers upon request suitable material which may be correlated with such studies as botany or nature studies, civics and geography. Much more effective work in this field could be done if funds were available for the printing of special bulletins or leaflets or for the preparation of special panels, each through a sequence of photographs telling the story of some phase of forestry. With the present limitation of funds but little of this kind of work can be done. The chief wardens, however, are requested to visit, if possible, each school in their counties during each fire season for the purpose of giving fire prevention talks and for distributing forest fire prevention literature. Effort is also being made to enlist the aid and cooperation of the county school superintendents in the furtherance of this important program.

Other lines of appeal which have been utilized by the State Forest Service are general publicity campaigns, including speeches, posters, window displays and signs, radio talks and special articles. All are intended to build up in the public mind

an appreciation of forest values and a fire consciousness which demand care with fire in or near woodlands.

Supplementing the educational or informational work, which no matter how intensively and efficiently conducted cannot be one hundred per cent effective, is a strict and impartial law enforcement program. Penalties must be imposed for carelessness with burning matches and smoking material, for leaving campfires unextinguished, for promiscuous and careless brush burning, for operating sawmills without the necessary precautions, and for the general setting of fires, whether intentionally or unintentionally. In addition, anyone responsible for starting forest fires, whether personally or through an agent or an employee, should be required to pay the cost of fire fighting. The State forest fire laws must be vigorously enforced, cordially supported by public opinion, and efficiently administered by an adequate protective organization.

For the third phase of the prevention program, reduction of physical hazards, effort is made to search out in advance every possible source of an avoidable fire, and to caution, warn and instruct as to the elimination of the danger. Railroad right-of-way clearings and sawmill inspections come within this category, and the chief wardens are instructed to inspect such possible hazards and endeavor by friendly cooperation to have the danger removed. Because brush burning operations constitute the greatest single cause of forest fires in Virginia, greatest emphasis is placed on work intended to reduce the number of fires which originate from this source. The chief wardens are instructed to determine as far in advance as possible, particularly prior to the spring fire season, the location of areas which are to be burned, and to interview as many persons as possible who will be responsible for such burnings. Advice is given as to proper precautions to be taken and a copy of the fire laws is left with each person thus interviewed.

Inherent Peculiarities of a Fire Control Organization

It must be frankly recognized and admitted that even with the best possible organization the State can put in the field to prevent forest fires, the dangers will always exist, and Virginia, for many years at least, will continue to suffer from fire losses. Nothing within the power of man can alter the degree of inflammability of the dry sedge grass of the Coastal Plain and Piedmont regions, nor of the hardwood leaves of the mountain sections. As a job, fire suppression takes precedence over all others, and it necessarily will occupy a prominent place in our work until the public fully appreciates the values at stake.

Fire suppression is and always will be a difficult problem.

The technique of extinguishing fires and other problems incidental to their suppression need to be studied by critical analysis of many individual suppression operations before our knowledge will suffice. Knowledge of the effect of weather conditions upon combustion, studies of susceptibility of various types of cover to ignition by cast-off matches, cigarettes, etc., are desirable, but are not the principal factors of control. The essentials are adequate detection and reporting systems and an intensive and efficient fire fighting organization.

The problem of a fire control organization differs from most other organization problems. It faces difficulties which to a large extent are peculiar to itself. Because the work of suppression is intermittent and yet demands unusual effort and often sustained activity day and night for long periods under hard conditions and at a low wage an unusual degree of loyalty and enthusiasm is required. For this reason a fire fighting organization must have and hold a high standard of morale and a strong *esprit de corps* to be effective, and this in spite of the fact that the personnel is ordinarily widely separated and can but seldom be brought together.

Preparation for Fire Suppression

The keynote of successful fire control is preparation. Such preparation should provide an adequate lookout system that will insure the quick detection of fires after inception, the means of promptly reporting them to the fire fighting organization, adequate transportation facilities in order that men and equipment may be moved to a fire without undue delay, and an efficient organization, fully equipped with fire fighting tools, prepared to go immediately to such fires as occur.

At the present time a fairly good start has been made in Virginia toward development of an adequate detection system. Eighty-four lookout stations, exclusive of those on the National Forests, have been built and are manned during the spring and fall fire seasons by the State Forest Service, in some cases with the cooperation of timberland owners. In order to link the detection, dispatching and suppression forces on the areas covered by these stations, the Service, largely through the CCC camps, has built and is maintaining about 700 miles of telephone lines. However, both the detection and communicating systems are inadequate and there is urgent need of funds to complete these systems as soon as possible.

Of equal importance with the provisions for the detection and the prompt reporting of fires, are the arrangements made, well in advance of the fire season, to insure adequate man power, supplied with competent leadership, on all fires. For the first line of defense dependence is placed in Virginia on the local forest

wardens and their registered fire crews. To combat unusually severe hazards, arrangements should be made where possible for reserve forces that will function harmoniously with the regular crews and who will be available for relief work. Adequate man power should not be thought of in terms of number of men, but rather in the quality of the personnel. Fire suppression in its various aspects requires endurance, technical skill and executive ability of high order. Without training and proper leadership, men will not function satisfactorily as cogs in the suppression machinery. With each suppression unit effort should be made, therefore, toward specific classification and assignment of individual duties so that all the personnel will work harmoniously and most effectively together. Tools, supplies, and equipment should be provided in standard units and coordinated with the sources of man power, and means of transportation, provided for well in advance of emergencies, should be procured to make readily available, in the shortest possible time, the men and tools needed at any fire.

The Technique of Fire Suppression

As to the actual technique of fire suppression, but little need be said for the purpose of this discussion. Emphasis must be placed upon prompt muster and dispatch of the organized forces under the best available leadership, immediate attack, day or night, and staying with the fire until the "last spark" is dead. Each fire presents a different problem and conditions on the ground must determine the proper method to be employed to most effectively control it. In general, however, the wardens are instructed to attack at a point or points showing promise of quickest control, which ordinarily is the head (or heads) of the fire and dangerous points on the flanks. On fires of such size that the warden in charge cannot determine at once the critical points requiring attack, it is essential that he scout around the area in order to determine what the best method of attack will be and where the men can be placed to the best advantage. Effort in Virginia is made to discourage back-firing over large areas and to encourage the direct method of attack as near the main lines of fire as possible. Moreover, on large fires, emphasis is placed upon the desirability of concentration of forces during the night and early morning hours when relative humidity and wind conditions are usually more favorable for effective fire fighting. The warden organization is seriously handicapped at the present by lack of lighting facilities, which are necessary to do effective fire fighting at night. For that matter, however, the organization is not supplied with adequate fire fighting tools and equipment of any sort, and there is urgent need of funds for the purchase of these essentials.

Splendid Service Performed by the Forest Wardens

The forest wardens of the State are to be commended for the splendid and unselfish service which they are performing. Hampered by lack of funds to provide for adequate organization and equipment, they have, in spite of this handicap, gradually reduced the area burned by the average fire in the organized territory from 49 acres, which was the average for the five-year period 1931-1935, to 23 acres for the period 1936-1940.

Much, of course, remains to be done. No one envisages the complete elimination of man-caused fires in Virginia, but with adequate financial backing, which is justified by the values involved, it is believed that the forest fire losses in Virginia can be reduced to such an extent that forest property will become an insurable risk. The ultimate goal is a forest-minded public which recognizes to such an extent the advantages of protecting our forests, not only because of their scenic beauty and recreational values, but also because of their wealth-producing possibilities, that they will be as careful with fire in the woods as they are in their homes.

Charlottesville, Va.

Destruction of Pinus Virginiana in the Bull Run Area by Girdling

H. A. Allard

Pinus virginiana Mill. is a very active invader of abandoned fields and pastures throughout the Bull Run area. In many localities these pines are rapidly extending their holdings in areas which formerly had been overgrown with a heavy cover of broomsedge *Andropogon scoparius* Michx.

For several years the writer has noted that some counteracting agency has been in persistent operation, causing the death of great numbers of these pines in the Bull Run area. Usually young pines only, ranging from 2 feet up to 8 or 10 feet in height, are attacked, but in one instance, a pine 5-6 inches in diameter at the ground and 15 feet or more in height had been completely girdled and killed. These are girdled just above the ground, by a narrow ring from which all the bark and cambium down to the wood has been so nearly or even completely removed, that the trees quickly die. These dead trees on high exposed pasture slopes soon blow or bend over as if their roots had decayed or had lost their normal attachment with the soil, or become weakened and broken at the point of girdling.

In some areas the young pines have been killed in great numbers, and it is evident that a serious check has been imposed upon the invasion of the pines in this area.

The writer has not specifically identified the animal responsible for this wholesale destruction, but the field mouse *Microtus pennsylvanicus pennsylvanicus* (Ord) is thought responsible for the visible girdling above the ground, although the pine mouse *Microtus pinetorum scalopsoides* (Audubon and Bachman) may also be present. The latter appear to be subterranean in their habits and destroy the bark of the roots more generally.

It is apparent that these creatures are especially fond of the resinous bark of the pine, although there are many other sources of vegetable food in this mountain region.

The Information Service of the Department of Interior on September 26, 1940, issued a press release, "Mice relish pine trees, but nurserymen don't like mice," which indicates great damage to pines in some nurseries by these mice. It is indicated that where several species of pines or conifers are present, a strong or even exclusive preference may be shown for one species alone.

In the Bull Run area, the writer has seen no examples of damage done to pitch pine *Pinus rigida* Mill., although it also occurs here, but in less abundance as our old field invader.

From an ecological point of view, these attacks in the Bull Run area are of considerable interest since we have here an example of serious interference with a normal succession by a natural biotic agency, which if continued may almost completely eliminate young invading pines in some localities, and divert the forest succession to one mainly of the hardwood trees.

Washington, D. C.

Applied Science, the Financial System, and Democracy

Allan T. Gwathmey

Editor's Note—For the last two years it has been the practice to include on the program of our annual meeting a few non-technical papers which might help in coordinating scientific knowledge or in relating the field of science to other fields of endeavour. It seems advisable to say a few words about the background of the following paper and its author.

After working in industry as an engineer and research chemist, the author became greatly impressed by the nation's tremendous ability to produce goods and services on one hand and its inability to get these goods over to consumers on the other. In the job of facilitating this distribution the author feels that the financial system has failed miserably. The word, "distribution" is not used in the sense of "redistribution" or "equal distribution", but simply in the sense of getting the goods from the producer to the consumer. The author does not believe that this failure in distribution has been produced in the main by the exploitation of the poor by the rich, by labor troubles, or by any of the commonly accepted reasons put forward today. Rather, he believes that the blame for the failure should be placed largely on the man-made conventions by which our financial system operates and that only by means of a definite and clear-cut change in these conventions will our financial be able to reflect the ever increasing physical wealth made possible in peace time by the application of scientific knowledge.

During the past few years, in addition to carrying out research on the mechanism of catalysis and corrosion, two fields of great importance in the expansion of industry, he has been engaged in a study of the correlation between our system of production and our system of finance. He has lectured on the subject a number of times and in 1938 was asked to write a paper which was read before the Committee on Banking and Currency, United States House of Representatives. At the present time he is continuing his studies in this field.

The views expressed in this paper represent those of the author and publication in the Journal in no way implies endorsement by the Academy or Board of Editors. The paper is presented for the consideration of our members. Furthermore, the author states that in a paper of this nature he is primarily concerned in defining the problem and discussing its background rather than in promoting any one specific set of proposals. The paper was written in the Spring of 1941, before war was declared, and should be considered from the point of view of that time.

At certain periods in the course of history, it becomes the duty, both from the standpoint of self-preservation as well as from an enlightened desire for more grace and dignity in living, for people who are specialists in restricted fields, to look beyond the boundaries of their specialties and to examine the relationships of their fields to other divisions of organized society. Today, in the age of specialization, this is more necessary than ever before, and if the individual parts of society cannot be fitted into a unified whole, then self-government, truth, and freedom, as we know them, cannot be.

This paper deals with a very practical problem. The application of scientific knowledge to our methods of production has greatly increased our physical wealth, but to our complete bewilderment this increased wealth is only reflected by unbalanced budgets, shortage of purchasing power, and general economic

instability. The richer we as a nation become physically, the worse condition we find ourselves in financially. It is the purpose of this paper to show that the so-called Scientific Age is being distorted and slowly thrown into disorder by an attempt to operate it under an out-of-date and unworkable system of finance. An effort will be made to show that only through a fundamental change in the conventions by which our financial system operates, will the people of our nation be able to purchase the many goods which they can now so easily produce.

This failure of the financial system has taken its toll in various ways in many parts of the world. In the midst of great physical wealth, a financial collapse almost tore our nation apart in the economic depression of ten years ago, and it now hangs over our heads like an impending disaster, threatening to make itself felt as soon as the false security of rearmament is brought to an end. Financial collapse, and the resulting economic chaos, contributed in a large measure to the overthrow of democracy in Europe. Let us not forget that during the last ten years this physically rich country of ours has only been able to keep its superb industrial system in operation by breaking the rules of orthodox finance to a greater and greater degree. A show-down on the financial problem is inevitable. Shall we evade the issue, or shall we face it consciously with a ready plan designed to produce a definite effect?

As I see it, there is no fundamental difficulty or fallacy in the democratic principles of self-government. The real difficulty, hidden behind the scenes, is the inability of democracy up to the present time to digest, or to bring into being as a living reality, the great age of possible plenty. Thus, the world is making the tragic mistake of discarding, or losing faith in, the democratic whole because one of its constituent parts is sick, and I believe that both facts and theory are showing with increasing clearness that it is our financial system which is very sick. In fact it is infecting the entire body, economic and social.

At the outset let there be no misunderstanding. This is not to be an attack on the rich or a criticism of individual bankers. It is hoped that this will be an objective consideration of those man-made conventions or rules by which our financial system operates. An attempt will be made to go behind the scenes and lay bare the essential features of our present system in order to understand wherein it fails to serve its appointed purpose.

The average hardworking person has, I believe, long wondered about the mysteries of the financial system, but he has been so baffled by its sophisticated terms and so restrained by the pressure of earning a living, that the best he has been able to do is to earn his pay-check and have faith that "all is for the best" in the most baffling and mysterious of all possible worlds, the financial one. The pressure of events is now forcing us, whether

we like it or not, to bring to trial this desperately important element of modern life. It is demanding that we develop a financial system which will have meaning in terms understandable to the average man.

In the past all of us in general, and the banking profession in particular, have made the serious error of accepting as God-given a set of financial conventions which developed largely during periods of great national strife when little or no attention could be paid to reason or the long-time economic stability of the country. These conventions ironically became known as "Sound Money", and we have been so impressed by the convincing word "Sound" that we have accepted these conventions as sacred and have failed disgracefully to re-examine them, in order to determine whether the financial system is serving its appointed purpose, which is the delivery of the nation's goods and services to the people of the nation. These conventions will be discussed later in detail.

Suppose that the scientific profession two hundred years ago had gotten together and selected a certain set of scientific principles and designated them as "True Science". Now suppose that we had become so delighted and impressed with the word, "True", that we failed to re-examine, or to change, our ideas about scientific truth, then think of what a hopeless condition our science would be in today. Galileo had to face and overcome just such a condition.

In my opinion finance is today where natural science was two hundred years ago. Anyone whose critical faculties have not been deadened by meaningless terms and preconceived ideas can see that we are living in the "Financial Dark Ages" in the midst of a world of possible plenty. What kind of a nation is it that can only keep its industrial system in operation when it is producing machines of destruction? What kind of a financial system do we have when the increased production of wanted goods results only in paralyzing debts and a general inability of the people to buy the products of their labor? What's the use of scientific workers, like you and me, struggling to wrench from jealous Nature her closely guarded secrets in the hopes of making the world a more secure place in which to live, if actually this increased knowledge, when applied to our system of production, only results in monstrous factories which stand idle because the consuming public do not have the necessary financial tickets to buy the wanted goods? Every man and woman today has a right to ask this question. It's preposterous to think that the problem cannot be solved. It's asking too much of a strong people to stand idly by and go without wanted goods because they can produce too much.

Before considering in some detail these financial conventions, let us briefly relate this problem to the subject of de-

mocracy. By a democracy is meant a system of government in which the supreme power is retained by the people but is indirectly exercised through a system of representation and delegated authority which is periodically renewed. Thus, by means of a vote the people as a whole can control the form of government under which they live, while certain safeguards such as freedom of speech are provided for the protection of minority groups. This is what might be called a political democracy and, during the early days of our nation, it was thought that such a system would assure the maximum freedom and development of the individual. The economic problems, it was hoped, would largely take care of themselves.

Now it is immediately obvious today, when public lands are no longer available and each of us is dependent on a highly interrelated industrial system, that this political democracy must be accompanied by what might be called an economic democracy. It is essential, if the individual is to have the maximum freedom and opportunity for development, that the right to vote be supplemented with the right to work plus an income. And if the right to work be denied due to the use of a machine, Mr. Kettering notwithstanding, or due to the incapacity of the worker, then the individual must be supplied with an income alone, certainly as long as crops are being destroyed and factories are running at half capacity. This is as plain as the nose on one's face, and we can build all the complicated and learned economic systems, we can fight all the wars in the world, we can cling to all the noble traditions of the past, but unless the people as a whole can purchase the goods which they now so easily produce, Democracy and its way of life haven't a chance of surviving in this country, in Germany, or anywhere else. The modern problem of Democracy is one of adaptability to new economic conditions and possibilities. Let us now shift to the economic side of the problem.

Economics, in the main, concerns itself with the production, distribution, and consumption of goods and services. Within a relatively short time this country has been converted from a wilderness into a rich land of farms, mines, and factories capable of furnishing the people of our nation with the necessities for a decent and secure life. It has now become a tiresome statement of fact that the problems of production have been relatively solved. Of course, we cannot push a button and get fifty thousand intricate warplanes within four months, but we shall probably get them within four years, a relatively short time in terms of economic change. As far as our peacetime economy is concerned, the application of science has enabled the farmer to grow more wheat and the shoemaker to make more shoes, but the farmer cannot buy the needed shoes or the shoemaker the wheat in sufficient quantities to keep them economically secure as consumers and financially solvent as producers. We might as well be frank

about it and admit that we have failed miserably to solve what should be the easier of the economic problems, that is, the problem of distribution.

Mr. Milo Perkins, of the Surplus Commodities Corporation of the United States Department of Agriculture, in speaking at the Institute of Public Affairs in Charlottesville last summer, said that the families of 80,000,000 people, nearly two-thirds of our population, live on an average cash income of $69 a month per family. He could hardly be accused of an overstatement when he said: "If anyone sitting in this audience had to bring up a couple of youngsters and try to take care of a home and educate these children on $69 a month, he would have a hard time." This is the true sore spot of Democracy. Raising the income of this family of four to $100 a month would probably mean more to the majority of people than the right to vote.

If our nation were actually deficient in physical wealth, we, as a people, might justifiably be called on to tolerate such conditions. But when warehouses are full and production is actually restricted for lack of orders, as is the case in our peacetime economy, human restraint and forbearance lose their significance. A serious depression which cuts the income in half makes the situation intolerable, and talk about the glories of democracy becomes meaningless.

Let us ask this question. What is the reason for this lack of orders in peacetime? Why don't our consumers buy more? There can be but one possible reason why a family of four, living on $69 a month, doesn't spend more money. They simply haven't got it to spend, that's all. Let us then in the name of self-government and of a decent, secure way of life strike hard at this deceptive problem of purchasing power or money income in the hands of the people.

The financial system deals with the management of money. Money consists of metal coin, paper money, and bank credit, or check-book money. Bank credit physically consists of ink-figures in the books of a bank and constitutes by far the larger part of our money supply. A unit of money is simply a ticket, the important difference between a movie ticket and a dollar bill being that the former is accepted at a movie theatre while a dollar bill is accepted anywhere by anybody in this country. A dollar bill is a kind of an All-American ticket.

The division of labor required by the application of scientific knowledge to our methods of production renders barter completely impractical today. A mechanic who makes a bolt cannot trade it at the mill for flour. The purpose of money, therefore, is to serve as a convenient medium of exchange in the production and distribution of goods and services. It is entirely a man-made

invention, just as much so as a pocket-knife or a fountain-pen. It operates according to certain conventions and not according to unchangeable decrees handed down from above as we are often asked to believe. Of course, once a certain set of financial conventions is adopted, definite mathematical results will then inherently follow, but the basic conventions, themselves, are man-made and changeable. Let us review briefly the historical origin of these conventions. Much of the mystery and ignorance about our money system may be removed by a knowledge of its origin.

Prior to the seventeenth century in England the government in the name of the crown coined all of the money which anyone was allowed to use. During the seventeenth century it became the practice of the London merchants to deposit their money in the Tower of London for safekeeping. But Charles I soon brought an end to this practice when he seized without notice all money so deposited. The owners of money then began to deposit their funds in the safeboxes of the goldsmiths who were willing to safeguard them in return for a small service charge. At first the depositor received a receipt slip from the goldsmith which entitled the owner to withdraw his cash on presentation of the slip. Around 1650 the goldsmiths, finding that only a fraction of the gold which had been deposited with them was ever withdrawn, hit upon the simple plan of issuing two or more receipt slips against one piece of gold. These receipt slips were, of course, the forerunner of the modern bank-note. To quote Mr. Hartley Withers, the well-known authority on British banking: the goldsmiths "conceived the epoch-making notion of giving notes (or receipts) not only to those who had deposited metal but to those who came to borrow it, and so founded modern banking".

By the latter half of the seventeenth century, the Stuart kings had reduced England to a state of bankruptcy, and William III, of Orange, had been made king largely by the Whig merchants in the hopes that a more stable government could be formed. But due to wars in France and political troubles at home, William and his councilors soon found that the revenue was a million pounds short of meeting expenses. After all means or raising funds, such as lotteries, taxing windows and bachelors, had been exhausted, the Chancellor of the Exchequer was forced, as a matter of expediency, to accept the proposals of a group of merchants in London who agreed to lend to the Government a little over a million pounds in gold in return for the right to issue Bank of England notes up to the full amount of the loan. Thus, in 1694, the Bank of England came into existence. Although not generally appreciated as such, this is one of the important events in history, for here for the first time the Bank, a private organization, got the right to create a paper pound note for every pound of gold it lent the government. It was a clear case of "eat-

ing their cake and having it too". With the formation of the Bank also came the invention of the standing national debt, the despair of all democratic governments today.

From 1694 down to the early 1800's, the Bank of England retained a practical monopoly over the creation of the nation's chief medium of exchange. By the end of the eighteenth century, the tremendous increase in productive facilities, made possible by the invention of the steam engine and power machinery, demanded an unprecedented increase in the supply of money. But this was largely prevented by the Bank of England which, while insisting on its monopoly of the right to issue bank notes and thereby preventing the formation of other banks of issue, made no attempt to establish branch banks in the provinces. A method of circumventing this monopoly of the Bank of England was soon found. Adopting the Dutch practice of settling transactions through the use of the check, new banks began to form in England which lent bank credit, or promises to pay, against a small amount of gold or Bank of England notes held in reserve. The Bank of England fought bitterly the formation of these banks, but finally the joint-stock banks with the right to issue credit money were legalized in 1833, and the Bank of England, a privately owned organization, shifted over about 1860 to its present position of a central bank which controls directly or indirectly the expansion and contraction of the total amount of money in the greater part of the British Commonwealth. It has been said that an Englishman worships one day a week at the Church of England and six days a week at the Bank of England, and no wonder when one considers the power at its disposal.

As for our own system in the United States, Alexander Hamilton, trained as a boy in an English counting house in the West Indies, simply superimposed on the United States, over the opposition of Thomas Jefferson, a banking system similar to the English system. Disagreement over these matters led to the formation of our two political parties, a fact which has long ago been lost sight of in the vague and high-sounding promises of both parties to give the country "Sound Money" without ever explaining clearly the significant issues involved. An attempt will be made to show later that it is imperative that our political parties now return to the issues which gave them their birth.

The abolition of the United States Bank, the establishment of the state banks, and the National Bank Act of 1860 simply shifted banking privileges, having to do largely with the right to issue money of various kinds and with the right to care for government funds, from one group of individuals to another. The Federal Reserve System served to coordinate and control the banking system without changing the fundamental mechanism of money creation.

Let us now throw the spotlight of our examination onto the

financial conventions which we have inherited from the preceding events and which for the past generation have been loosely bandied about under the term "Sound Money".

1. The first convention is that a paper dollar or a dollar of bank credit is always redeemable on demand in a certain weight of gold. Since ten dollars of bank credit could never be redeemed by roughly three dollars worth of gold if all the depositors made claims at once, a series of depressions of increasing intensity showed that this convention was impractical, and we are now prohibited by law from obtaining gold. As has been pointed out by others, this feature of redeemability in gold only held if you didn't want the gold, a feature which never tended to inspire much confidence in the soundness of our system. Furthermore, an attempt on the part of the banks during a depression to decrease the quantity of redeemable deposits by calling loans, generally accelerated the financial collapse. However this feature of redeemability in gold is probably dead forever and no more nails need be driven into its coffin.

2. The second convention is that the total amount of bank deposits, which in the main is made up of bank credit or promises to pay, as recorded in the books of banks, is limited in amount to an arbitrary multiple of the amount of reserve deposits (which are ink-figures) recorded in the books of the Federal Reserve Banks which, in turn, are limited to an arbitrary multiple of the quantity of gold in storage. To summarize, the quantity of money in this country is limited in the main to a certain multiple of our quantity of gold. Through the discount rate, and the purchase and the sale of securities, the explanation of which need not concern us here, the Federal Reserve Banks control the supply of reserves and hence attempt to control the total quantity of bank deposits in the country.

Regardless of many learned arguments about the automatic flow of gold from one country to another or about the convenience of gold as a basis for control, the fallacy of relating the quantity of money in a nation to the quantity of gold is now obvious. A nation may have no gold, yet be very rich physically, and therefore require a large quantity of money to facilitate the production and distribution of goods. On the contrary, it may have more gold than is required for the purpose of control, as is the case in this country today. Obviously the quantity of money should be directly related to the amount of the physical wealth. Gold is an unnecessary, and often disastrous, complication.

Thus the second convention of relating our supply of money to our supply of gold seems to be pretty well doomed and it is quite probable that gold as a basis for the control of deposits will be largely ignored, at least for the present. The third convention is, however, still well entrenched and its significance is considerably more difficult to understand than the first two. It

is, I believe, proving to be as impractical as the others although its faulty features cannot be so easily exposed.

3. The third convention has to do with the method by which we increase our supply of money and the manner in which we inject this new money into the economic system. The average man in the street seems to have a vague idea that the government creates the nation's money and that the banks simply act as custodians or agents for this money once it has been distributed by a method, never quite clear, into the economic system. This false impression that the government creates the nation's money probably arises from the fact that the government does operate the mint and print dollar bills, but even these bills are largely printed for the private banking system. It would come as quite a shock, I believe, to the average voter to find that his government, or his "Uncle Sam", does not create the country's medium of exchange but that the private banking system with few exceptions manufactures the nation's money just as surely as a shoemaker manufactures shoes. Yet this is probably the most important single feature of our economic system. During the last few years the public has been becoming increasily aware of the fact that when our government sells a bond to the banking system, the latter pays for the bond with money which it creates by a simple bookkeeping entry.

The third man-made convention by which our financial system operates is therefore: the making of a commercial loan or the purchase of certain types of securities by the banking system results in an increase in our total supply of money. It does not result, as most people think, simply in a shift of already existing money from one account to another with no attending increase in the total. The repayment of a loan or the sale of a security likewise results in a decrease in our supply of money. Hence the mechanism for making commercial loans and purchasing securities is directly connected with the mechanism for increasing our supply of money, two rather strange economic bed-fellows. For, as will be shown later, it may be essential to increase the quantity of money in the hands of customers without increasing our indebtedness to the banking system. Except in a few cases this is impossible under the present system. Furthermore, it is bad in principle to allow an institution which earns its income by dealing in money, to have the final word in deciding how much money the nation shall have at any one time.

It should be remembered that this all-powerful third convention had its origin in the dubious practice of the goldsmith of issuing two receipt slips against one piece of depositor's gold and lending the second receipt slip. There is absolutely nothing sacred about it as we are often asked to believe, and preposterous arguments have been advanced in the past to show that it is the *sine qua non* of "Sound Money". Aside from the dispropor-

tionate power which it gives to the banks in their control over our money supply, what then are the objections to this third convention?

Orthodox economics has grown up under the assumption that the financing of production automatically finances consumption. This simply means that if the total cost of producing a certain article is $100 then there will be available in the hands of consumers $100 with which to buy the article. This assumption fits in nicely with the third financial convention for, if a manufacturer borrows $100 from a bank, $100 of new money comes into existence, the manufacturer pays out the money in the production of the article, a corresponding amount of money finally reaches the hands of consumers who can then purchase the article, the producer recovers his $100 which enables him either to go through another cycle of production or to repay his loan and go out of business. Thus it is argued that there can be no need for new money which does not come into existence as a debt or a loan to producers. In fact, it is generally argued that the creation of money which has no debt attached will produce inflation or a price rise due to an excess of money over goods.

Now not only do the actual facts before our eyes today disagree with the naive assumption that consumers as a whole have sufficient purchasing power to meet the minimum retail price of the goods for sale, but there are very good theoretical reasons why this cannot be so. A thorough discussion of these reasons is beyond the scope of this article, but, in brief, this deficiency of consumer purchasing power is produced by the fact that there are a number of costs which must enter into the price of manufactured articles which are not covered by the distribution of a corresponding amount of purchasing power. Such uncovered elements of cost are produced by (a) the allocation of charges for certain reserves, surplus, and undivided profits; (b) savings, and reinvestment of wages, salaries, and dividends in the production of new goods; (c) the premature concellation of purchasing power before the liquidation of the costs created by the distribution of that purchasing power. This last factor may not be effective during a period of constant economic activity but becomes of great importance when economic activity is curtailed for any reason whatever, such as will be the case at the end of the present war.

Now regardless of the validity of this theoretical explanation, it is certainly a fact that this shortage of consumer purchasing power exists, and this is the important point for our purpose. Evidence for this shortage is: the necessity for large government expenditures in order to put money into the hands of buyers; installment buying, which is a scheme fostered by industry itself to dispose of goods for which no purchasing power is available; restriction of the production of wanted goods in its various

forms; and a desire on behalf of producers for an excess of exports over imports. Not one of these makeshift schemes would be necessary if a shortage of consumer purchasing power did not exist. Increasing the velocity of circulation of money will not, in the main, make up for the shortage, for this increases the rate of generation of price values as well as the rate of distribution of purchasing power, the ratio between the two remaining approximately the same.

The all-powerful effect which purchasing power has on industry may be strikingly seen today. Right before our very eyes we can see how rapidly industry expands when it is assured of sufficient purchasing power and at the end of this war we shall tragically see what happens when the purchasing power is cut off. The inexcusable feature is that the machines which will be stopped will not know the difference between a war on another country and a war on poverty and insecurity. The difference is all in the account books.

Of course, many proposals have been made for the solution of our economic evils; these range from a strict return to the gold standard to the complete abolition of private property. Time will not allow a discussion of each of these.

The most effective proposals which have been made, it seems to me, are those which strike directly at the root-cause producing this shortage of purchasing power, that is, our conventional method of bringing new money into our economic system. These proposals call for the disruption of no existing institution, and they will be briefly described. They were first put forward by the British economist, C. H. Douglas. In principle it is proposed that a limited amount of new money be periodically issued direct to the consumer in sufficient quantity to make up for this chronic shortage of purchasing power, no more and no less. This would simply enable the people of the nation, as a whole, to buy the goods which they can so easily produce. It would enable industry to remain financially solvent as production increases. Under the present system we are powerless to do either except by unbalancing the national budget.

First, the quantity of new money to be issued is to be periodically determined by the difference between the total production and consumption of goods and services for the current period. Thus, new money is to be created when there are new goods to match, and additions to our money supply would not then be entirely dependent on a desire for commercial loans or on a market for securities, as is the case today. If the producer cannot sell what he has already produced, it is futile to expect him to borrow more money in order to expand his production. Second, this new money is to be created by the government by a bookkeeping transaction and is to be debited against the nation's increase in real wealth. It is to enter the economic system as a credit or dividend

to the consumer and not as a debt or loan to the producer. The money is not to be obtained by borrowing from the banking system which, according to the convention inherited from the goldsmiths of the seventeenth century, simply create it by a bookkeeping transaction and thereby increase indebtedness. Thus, it is proposed to furnish an effective market for the surplus production. For example, if for the current period total production amounted to ten billion dollars and consumption to eight, two billion dollars would be issued to consumers as a whole. Thus, the consumer could buy the goods and the producer could recover his costs which would enable him to go through another cycle of production and finally to expand his capacity by increasing his loans or sale of securities if desired. This is most definitely not inflation for goods and money are increased at the same rate. Once this money enters the economic system, it would be indistinguishable from any other dollar.

These proposals are unique in that it is proposed that the financial system be periodically and directly related to a statement of the physical wealth of the country. Certainly, there is no possible method by which the financial system can reflect the production of goods unless the nation regularly draw up an approximate statement of the quantity of goods which it is supposed to reflect. These figures are not as difficult to obtain as they might first appear and many of them are already available in the various trade associations and government bureaus. The figures for production would include all goods and services, wholesale and retail, produced during the past period, say of three months. For example in the case of a shoe manufacturer, the necessary figures for production would be the number of shoes produced times the market price of a pair of shoes. The figures for consumption would include all goods and services, wholesale and retail, which have been sold or consumed including the depreciation on capital equipment. Each producer would report his figures to his trade association, which in turn would report their figures to the Treasury Department, which would assemble a total figure for the nation. To say that such figures cannot be obtained is to admit that we as a nation can build the most complicated radios and automobiles but that we can't count the number we produce or the number we consume. No one producer can benefit by overstating his production or consumption, and the figures required need only be approximate.

There are several methods by which these periodic additions of money may be distributed. The simplest method is the payment of an equal dividend to everyone of age, rich and poor alike. The amount available would probably be in the neighborhood of $5 to $10 per person per month which is a small increase for those in the higher income groups but a very appreciable increase for the majority of people. The total national income

would be increased 10 to 20 per cent during the first year by such a dividend.

Now whenever a suggestion is made that the quantity of money be increased for any reason whatever, the issue always becomes immediately confused by the misleading cry of inflation. In fact many people become frightened at the mere thought of large numbers when applied to financial matters, although there seems to be no objection whatever to the fact that there are 6×10^{23} molecules in 32 grams of oxygen. The problem of the quantity of money is quite simple if two figures are kept in mind: one, the quantity of goods; and the other, the quantity of money. Starting with any one price level, if the quantity of money in the hands of consumers is increased at the same rate as the quantity of goods, this definitely does not produce inflation, which may be defined as a price rise, or a depreciation in the value of a unit of money. Reference to inflation in Germany after the last World War, when the quantity of goods was small and the amount of money was greatly increased, is entirely beside the point. A man may die of thirst from a shortage of water or drown from an excess and somewhere in between is the proper amount. In economics the proper amount of money in the hands of consumers is that which is just equal to the price value of the goods for sale, and it is this amount which these proposals are designed to assure.

Thus by these simple changes in our financial conventions, the people as a whole would always be able to buy the goods which they can now so easily produce. The only limit to our industrial expansion in the future is the saturation of the people's desire on one hand and the inherent limitation of our capacity to expand on the other. At present there seems to be no limit to either. When two-thirds of our families live on a cash income of about $70 per family per month, there is no need to worry about saturating the desires of our people for a long time to come. If that time should ever come, then there would be no need for an increased purchasing power.

These proposals in no way interfere with existing institutions or present methods of obtaining incomes. The present banking system may, in the main, be retained and these proposals made entirely supplementary to it. There are a number of modifications of these proposals and their application to particular situations has been worked out in considerable detail which cannot be described here.

It is obvious that these proposals would render unnecessary most of the temporary expedients which the government has been forced to adopt in an attempt to maintain consumer purchasing power and keep industry solvent. Most of the relief work and a great deal of the forced charity of today would be eliminated.

The ethical basis for this small free dividend is that it repre-

sents the cultural inheritance of each citizen from the accumulated store of knowledge of organized society. It represents your inheritance and mine from the invention of the steam engine, the dynamo, and from the many divisions of organized society which have made possible this continual expansion of our ability to produce. These proposals simply bridge the gap between our ability to produce and our ability to purchase or consume. The present system is powerless to provide more than a makeshift.

Since our entire discussion thus far has been concerned with a peacetime economy, a few words should be said about the proper methods of financing the expenses of armaments. They are quite simple in principle. The undesired inflation usually accompanying a period of great expenditure on armaments is produced by the fact that money paid out to individuals in the production of both war supplies and peace-time consumable goods is spent by those individuals to buy only consumable goods, and, since the purchasing power then exceeds the price value of consumable goods, a price rise follows. Certainly there is no great mystery about this and in order to prevent this price rise, taxes should recover the excess of purchasing power over the price value of consumable goods. In other words, taxes should always recover that fraction of the total income which the production of arms bears to total production.

Now you may not approve of these particular proposals, and I in no way wish to insist that you do, although I, myself, support them to the limit. The real object of outlining them at this meeting is to offer for your consideration a rather new approach to our financial and economic problem, an approach which calls for a definite change in one of the conventions by which we operate our financial system. These proposals call for what, in effect, might be termed a "Bookkeeping Revolution" which would make the figures of our financial system correspond more nearly to reality. When great physical wealth abounds in our land, but only our financial system tells us that, according to our books, we haven't the money-tickets necessary to buy the goods available, then clearly a revolution in our methods of keeping books is just what is needed. The brief historical account of the development of our present system has shown its purely conventional nature and how easily it might be changed, once the nature of the problem is appreciated. These proposals are not offered as a cure-all for the shortcomings of mankind but they are offered as the solution of a basic problem which lies at the bottom of many of the more obvious difficulties of our times.

But regardless of what proposals you may wish to support, if economic chaos is to be prevented at the end of this war, if the elements of internal strife which are undermining democracy are to be removed, then this gap between physical wealth and the financial system must be closed. This is the burden of my paper.

The scientific profession, which has furnished the technical knowledge and skill largely responsible for this great increase in wealth, has both a right and a duty to demand that the financial system be made to reflect this wealth rather than to restrict or distort it.

We have a right, as a body, to say in effect to those who direct our financial system, "Here is the scientific knowledge, here are the industrial processes, here are trained workers and abundant raw materials. It is evident to everyone that our physical wealth is very great and our potential wealth almost unlimited. The desires of our people, too, are far from being saturated. Why is it, then, that, in spite of all this, our financial system tells us that we have a national debt of forty billion dollars? Why is it that the people of our land do not, except during the false security of rearmament, have sufficient money tickets to purchase the goods which they can so easily produce? How can you explain these things and what do you propose to do about them?" This is a perfectly fair and justifiable question for the scientific profession to ask of the financial profession, and don't let us be satisfied until we get a direct and reasonable answer. Let us not accept such replies as, "You can't change human nature" or "You can't tinker with the financial system, for look what happened to Germany at the end of the last war". I say look what *has* happened to Germany, after having been told a few years ago that there was no need to worry about Germany for she didn't have any money.

This problem of the modernization of the financial system is one of peculiar difficulty, for it involves the realization of an elusive fault in a system of our own making. It is a problem which has so far defied solution but which must now be solved in this country if democracy is to survive. Its scope and its breadth may make you feel that it is far removed from this quiet meeting of the Chemistry Section of the Virginia Academy of Science. But ideas, which must precede effective action, move in the beginning in a small and quiet way, and they have been moving in this State in the name of freedom for a long, long time.

This struggle for freedom and democracy is no new romantic fad to the State of Virginia. In this great crisis in history, it now becomes once again the duty of Virginia, her people, and her institutions to do their share in the name of freedom and security, to lead the way in the establishment of an economic, as well as a political, democracy in which the people as a whole, high and low, black and white, will receive the many benefits possible in this so-called Scientific Age.

As a member of the Virginia Academy of Science, an institution dedicated to truth in a state devoted to freedom, I, for one, swear that I shall not rest until this intolerable and unnecessary contradiction between physical wealth and our financial

condition shall be removed. I hope that the Academy, as an institution, will use its influence, as it sees fit, to assure that no artificial barriers, financial or otherwise, will come between scientific knowledge and the reasonable application of that knowledge to the banishment of poverty, disease, and insecurity from our land.

UNIVERSITY OF VIRGINIA.

Methods of Hatching Eggs of the Blue Crab[1]

Margaret S. Lochhead and Curtis L. Newcombe

Introduction

The blue crab, *Callinectes sapidus* Rathbun, is the only important marketable crustacean in Chesapeake Bay. While this body of water may be regarded as a center of its numerical distribution, blue crabs in the United States range from Cape Cod south to Texas. Their economic importance is indicated by records of the Federal Government which report for the four-year period 1936-39, an annual average of over 82 million hard crabs valued at about $526,000 from Virginia and 56 million worth about $382,000 from Maryland. Soft crab catches in the two states during this period were approximately the same, amounting in each case to over 10 million crabs per year valued at about $210,000. The commercial value of this fishery, shared by Maryland and Virginia, to local tidewater communities warrants careful examination of the economic and production trends in their relation to sound conservation practice.

In view of the need for information on the early development of the blue crab, studies were begun at the Virginia Fisheries Laboratory in 1940. An effort was made to develop a hatching technic for crab eggs under laboratory conditions that might open the way for large scale application under natural conditions. During the summer of 1941, the crab work was extended and intensified in view of reports of a serious shortage of soft crabs, particularly in Maryland. Aiming to answer questions of practical value to the industry and to crab conservation, studies on the hatching of eggs and experiments on water conditions as they affect hatching and survival of crab larvae were stressed.

Egg bearing or "sponge" crabs predominate during summer in the waters of the lower Bay. Large quantities of egg masses or "sponges" are destroyed when these crabs are steamed in commercial houses. This loss of live eggs has raised the question of whether or not a way may be found to *detach* the egg masses from the crabs when they are landed at the crab house, transfer them to the laboratory, hatch them out there and liberate the larvae to local waters, thus reducing a present waste. The specific objectives involved in this undertaking are—firstly, to develop a satisfactory technic for removing the "sponges" from the crab and transporting them from the commercial crab house to the laboratory; secondly, to find a method of keeping these egg masses

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[1]Contribution number 9 from the Virginia Fisheries Laboratory and Department of Biology, College of William and Mary.

in a normal condition during varying periods in the laboratory until facilities are available for hatching them; thirdly, to develop a technic for removing small numbers of eggs from the "sponge" preparatory to actual hatching; fourthly, to discover the technics and environmental conditions that are needed for hatching the eggs to the first true zoeal stage; fifthly, to rear first zoeal stage larvae through a series of moults; and sixthly, to find a suitable method for liberating the hatched larvae to waters of the Bay so as to assure survival.

It is the opinion of some investigators that such attempts are not likely to prove fruitful. Needless to say there are many pitfalls to be overcome and an ultimate goal of rearing large quantities of young crabs through all the larval stages preparatory to their liberation in the Bay waters is admittedly not yet in sight. However, the liberation of early zoeal stages hatched from detached "sponges" of commercial crabs is now no longer a problem. The practical benefits likely to accrue from the conversion of an otherwise wasted "sponge" into thousands of larval crabs is not without significance. Expectedly, many will be devoured by predators but this is a natural phenomenon that goes on whether the larvae have a natural or an artificial origin. Presumably, the older the stage in which vigorous larvae are liberated the better their chance of survival but this is by no means a certainty. The success reported by Barnes (1939) in hatching the eggs and rearing the young of lobsters in New England lends encouragement to crab hatching experiments.

An attempt to develop a technic for successful hatching of blue crab eggs on a large scale was undertaken for a second reason, namely, to permit experiments designed to tell under what natural conditions of environment, particularly salinity, eggs may be expected to hatch. In other words, will the eggs of "sponge" crabs occurring off Mobjack Bay or Buckroe Beach hatch out under the salinity conditions that exist there, or do these crabs migrate to the higher salinity waters of the Capes for hatching purposes, or do they simply remain and the eggs fail to hatch out normally? The question of migration may be answered through tagging experiments. Answers to the other questions may be obtained in large measure by carefully controlled hatching experiments. This information is expected to aid in the selection of proper boundaries for crab sanctuaries. For example, if it is found that "sponge" crabs do not undergo a significant migration to the saltier waters of the Capes (a question on which there still seems to be some doubt) then whether they should or should not be protected in areas of less saline water away from the Capes depends on whether or not the eggs will hatch successfully in these areas. These and related probelms have important bearing on some of the practical aspects of crab conservation.

There is little, if any, information in the literature on the hatching of blue crab eggs detached from the parent. Churchill (1921), working at Hampton, Virginia during 1916-17, recorded that two "sponge" crabs kept on floats hatched their eggs. Later, Truitt (1939, p. 15) also reported that under laboratory conditions eggs developed and hatched when attached to the mother, but that it was impossible to hatch out eggs which were detached from the parent. This paper presents this Laboratory's findings to date on how successful hatching of detached eggs may be achieved under laboratory and field conditions and also how moulting of the first true zoeal stage to the second instar was obtained.

Review of Life History

A brief review of existing information on the biology of the blue crab follows. In the less saline waters of the Bay proper and the estuarine waters of the numerous rivers flowing into the Bay, the crabs mature sexually. Here, they mate during the summer at which time the spermatozoa received by the female are stored in special receptacles until the following spring and summer, when the eggs are laid. Whereas the males largely remain in the headwaters, the females start a southern migration reaching the more saline waters of the lower Bay and being ready to lay their eggs by the following spring (Churchill, 1921). The eggs leaving the ovary pass through the seminal vesicles where impregnation by the stored spermatozoa probably takes place and pass down the oviducts to the outside. On leaving the oviducal openings, the eggs become covered with a transparent shell and are cemented to the hairs of the pleopods forming a large egg mass under the abdomen known locally as the "sponge". The "sponge" has been variously estimated to contain from 1,700,000 to 4,000,000 eggs (Smith, 1885; Paulmier, 1903; Churchill, 1921). Churchill's observations on two captive crabs indicate that the incubation period is about two weeks. The life cycle is completed when the young that develop from these eggs undergo successive moults and migrate toward less saline waters of the rivers and upper Bay reaching maturity the following spring and summer at an age of about one year.

Materials

"Sponges" used in the experiments reported here were obtained from fresh crabs in the packing houses at Hampton and Seaford and also from those caught in the York River. They were transported to the laboratory either while attached to the mother crab or in a detached condition. The color of the "sponges" in nature provides a general indication of time of hatching. During the first part of the incubation period, the

"sponge" is yellow in color whereas about five days before hatching-time the eggs darken and finally become dark brown. This is due to changes in their embryonic development. If the embryo moves vigorously and the eyes have developed distinct ommatidia, the eggs are ready to hatch in about a day. When the eggs are within about five days of hatching, it is possible to estimate the hatching time with an accuracy of twenty-four hours.

Uniformity in the developmental stages of the embryos of a "sponge" seems to be a rule. Miss Rosalie Rogers, who assisted in this work, made counts on sixteen different "sponges" and found that only one to four per cent of the eggs of an entire "sponge" were in retarded or undeveloped stages. Eggs taken from the outside and the inside of the "sponge" gave similar hatching results.

Most hatching experiments were carried out in York River water of a salinity varying from nineteen to twenty-one parts per thousand. The temperature of the water in the hatching containers usually ranged from 24 to 27° C. On July 28, 31 and August 10 the temperature was as high as 31° C. When running water was used, the temperature remained around 20° C.

Technics and Experiments

Technic of Transportation. As soon as the fishermen brought their catches into the packing houses, active "sponge" crabs were selected and transferred to the laboratory in containers without water. Best results were obtained by transporting detached "sponges" in jars protected from sunlight and not containing water. When the air temperature was above 30° C. and the period of transportation was two hours or more, the containers were surrounded by a layer of ice.

Technic of Removing Eggs. In removing the whole egg mass, the following method was used. Each pleopod was cut off at the base with a pair of scissors, care being taken to hold the crab so that escaping blood which clots quickly would not cover the eggs and prevent their hatching. The detached sponge remains as a unit and as such may be taken to the laboratory and the eggs removed to hatching jars as described below. Instead of transporting the sponge as a single unit, it may be divided into eight parts by pulling apart the eight pleopods thus providing better aeration and favoring higher survival during transportation to the laboratory.

Two methods of removing the eggs from the sponge mass to the hatching jars in the laboratory were tried. One consisted of removing individual fine strands, 10 to 20 mm. in length, bearing eggs, by means of needles and forceps. These strands were then placed in the hatching jars in the desired quantity. A second

rather crude method, that nevertheless yielded good results, was to slice off of the sponge with scissors an extremely thin section leaving a narrow line of eggs on the blade. On submerging the blade in the water of the hatching jar, the eggs fall off and sink to the bottom. Care should be exercised to keep the strands well separated and to prevent a close grouping of the individual eggs that fall from the blades of the scissors. This method was quicker and hence more commonly used. Thus far, no attempt has been made to hatch out all the eggs of a particular sponge but no special difficulty is anticipated. Experience has shown that some eggs are injured in both methods.

Hatching in Aquarium. The eight pleopods of a "sponge" with eggs attached were tied together loosely and suspended in the middle of an aquarium 32 cm. wide, 60 cm. long and 30 cm. deep. Air bubbles and jets of circulating sea-water penetrated the inside of the egg mass stirring the eggs constantly. Many of the eggs hatched, almost all of which were in incompletely developed stages. During the process of hatching, decomposition set in and the larvae died before reaching the first zoeal stage (Table I).

Hatching in Tall Jar. The use of tall jars with water depth of about eight cm. gave a ninety per cent hatching result only if an average concentration of about 8 eggs per square centimeter of bottom surface was used. Increasing the water depth did not permit the use of more eggs. As soon as the number of eggs was increased the hatching per cent decreased. Eggs in heaps of over three millimeters depth failed to hatch.

Hatching in Plunger Jar. By using the plunger-jar mechanism (modified after Harvey, 1928), the highest hatching percentage achieved was sixty. For a three liter capacity jar one pleopod with attached eggs, i.e. one-eighth of the entire "sponge", was used. The pleopod was cut in from two to four parts and each part attached by threads to the disk of the plunger. At the time of hatching decomposition set in and many of the larvae were in incompletely developed stages and soon died. These conditions were not improved by using running water and additional aeration.

Hatching in Shallow Pan. White enamel pans about 20 centimeters wide and 26 centimeters long were found to be the most satisfactory for hatching the eggs (Table I). The depth of water in the hatching dishes varied from one to six centimeters. Eggs numbering about eight per square centimeter of surface on strands, from one to five mm. long, were placed in the containers. If the eggs were within one or two days of hatching the dishes were often left uncovered. In the beginning, the hatching results were variable due to faulty technics. Best percentages (80-90) were obtained in August when an improvement in the method was worked out.

If several days were required for hatching, either the containers were covered or the sea-water was exchanged every second day. This method was used successfully with eggs ready to hatch in ten or fourteen days. Due to limitations in space, equipment and time few experiments were conducted with such eggs and hatching percentages were not determined.

The shallow pan method of hatching the eggs is simple, gives high hatching percentages and yields vigorous larvae. However, the relative number of eggs which could be hatched in any given container was small. When the number of eggs in the hatching container was increased, decomposition set in, the hatching percentage decreased and the zoeae emerged in incompletely developed stages. It was found repeatedly that by using an average of about eight eggs per square centimeter of surface a hatching percentage as high as 90 may be regularly obtained.

TABLE I

SUMMARY OF EXPERIMENTAL RESULTS ON HATCHING OF CRAB EGGS

Container	Approximate number of eggs used in individual containers	Highest hatching percentage obtained	Number of experiments	Date of start of experiments
Aquarium 32 x 60 x 30 cm. (water depth)	about two millions	5	3	July 15, 20 and 23.
Plunger jars dia.—12 to 17 cm. water depth—15 to 20 cm.	about 200,000	60	17	July 3, 8, 10, 19, and 24.
Jars dia.—12 to 17 cm. water depth—15 to 20 cm.	100,000 to 200,000	10	18	July 7, 10, 24, 29 Aug. 2 and 4.
Jars dia.—12 to 17 cm. water depth—15 to 20 cm.	1,800	90	18	July 7, 10, 24, 29, Aug. 2 and 4.
Shallow Pans July experiments 26 by 20 cm., water depth—1 to 6 cm.	50,000 to 3,500	35	60	July 3, 23, 24, 28, 29, and 30.
Shallow Pans August experiments 26 by 20 cm., water depth—1 to 6 cm.	3,500	90	60	July 31, Aug. 1, 2, 5, 11, and Sept. 5.

Hatching in the York River. A preliminary experiment was carried out on the hatching of eggs in the York River. The pleopods with eggs attached were fastened in a box made of wire mosquito netting. The box was then suspended in the York

River at Yorktown. These eggs were ready to hatch within twenty-four hours when placed in the River. The following day the eggs were taken to the laboratory and examined microscopically. Examination showed that many of the eggs had hatched and that many were still unhatched but contained living embryos. The hatched eggs showed that in many cases the inner egg membrane was left attached to the outer shell. According to our observations this can be taken as a fairly definite indication that the larvae hatched in a healthy condition. This experiment was carried out on September fifth. Lack of "sponge" crabs after this date prevented the continuation of these experiments.

Development of Larvae. While the experiments on rearing of crab larvae are not germane to the main thesis of this paper, it may be pointed out that a moulting of the first true zoeal stage was accomplished. Numerous attempts were made without success using a wide variety of foods and environmental conditions. Finally, by selecting as food a particular and as yet unidentified dinoflagellate extremely abundant periodically in York River waters during summer, it was possible to obtain moulting of the first zoeal stage.

Various Observations Connected with Hatching. There seems to be no particular time of day when the larvae emerge. We observed hatching at various hours during day and night.

The majority of the eggs of a given sponge hatched out uniformly within twenty-four hours, a few requiring additional time. In some instances new larvae were obtained three days after hatching had commenced, but they were found to succumb soon. Larvae which are healthy at the time of hatching, shed the inner egg membrane and the prezoeal skin within a relatively short time. When conditions are unfavorable they fail to do this and may remain enclosed in the prezoeal skin for some hours or until they die.

In an attempt to find a means of keeping the egg masses in a normal condition during varying periods in the laboratory until facilities are available for hatching, the eggs were subjected to low temperatures. It was found that eggs would hatch normal larvae after being kept without water at 10° to 12° C. for forty-two hours.

Results

Egg masses or "sponges" for hatching purposes were detached from the parent by severing each pleopod, to which the eggs are attached, at the base exercising care to keep escaping blood from the eggs. In transporting detached "sponges" to the laboratory, it was found desirable to keep them in jars protected from sunlight and not containing water. "Sponges" were stored at the laboratory awaiting hatching for at least forty-

two hours by maintaining them at temperatures around 11° C. It was found that a very small number of eggs should be placed in the hatching jars to secure best results.

Numerous experiments have shown that, under proper conditions for development, eggs removed from mother crabs hatch and yield vigorous larvae. Eggs requiring as many as fourteen days for development were hatched out successfully in the laboratory. However, in most of the experiments eggs ready to hatch within from one to four days were used. Since the normal incubation period is believed to be about two weeks, it is postulated that eggs may be detached at any time during this period and induced to hatch under laboratory conditions.

Best hatching results were obtained when small numbers of eggs were kept in large containers. Using egg masses that were in good condition, a ninety per cent hatch was readily obtained when the concentration of eggs was about eight per one square centimeter area of bottom surface.

Moulting to the second zoeal stage of this crab is reported for the first time. These zoeae fed on an abundant local dinoflagellate.

Preliminary results of hatching under natural conditions of the York River, in contrast to laboratory conditions, were positive. Although more experiments are still needed, the data seem to indicate definite possibilities for the application of this method as a practical means for producing large numbers of zoeae from sponges that are not now utilized by the industry.

Discussion

The hatching technics described here have direct bearing on how "sponges" now wasted in the crab industry may be utilized for producing larvae. The problem of transporting detached egg masses to the laboratory in a healthy condition has received some attention. When the time required is not over two hours, they may simply be transferred in a jar. However, should large scale handling of "sponges" be undertaken, a need would arise not only for holding them during a longer period required for transportation but also for keeping them in the laboratory during preparation of the necessary conditions for hatching. Storage experiments have shown that eggs kept at a temperature around 11° C. for as long as forty-two hours still hatched on removal to favorable conditions.

While an eighty to ninety per cent hatch has been readily obtained in the laboratory, the findings to date show that a very large hatchery would be needed to accommodate any appreciable daily supply of "sponges". It was for this reason that the York River experiments in natural waters were undertaken. A continuation of these studies is aimed to offer the best results from

an immediate practical standpoint. It is recognized that, although under experimental conditions hatching does take place in the York River waters of twenty parts per thousand concentration, there is no information as to whether or not the larvae are able to survive and moult normally in these waters. That they have moulted into the second zoeal stage in the laboratory suggests the possibility of these waters supporting a normal growth of artificially hatched zoeae, but on this point there is no definite information. More experiments are needed.

Hyman (1920 and 1925) observed that fiddler crabs and some Pinnotherids hatched at dusk, whereas the xanthid, *Menippe mercenaria* seemed to hatch at any hour of day or night. Truitt (1939, p. 15), referring to the hatching of blue crab eggs while they were still attached to the parent, states that hatching takes place during early evening especially about nine o'clock. In our experiments hatching occurred at various hours of day and night and it has not been possible to attach significance to any particular factor as governing the time of emergence of the larvae when, from the observer's standpoint, environmental conditions were favorable.

Having worked out satisfactory hatching technics, it is now possible to obtain an abundant supply of zoeae for studying the environmental conditions that are favorable and unfavorable for the survival of early larval stages. This points the way to an understanding of what natural waters are best suited for hatching and early development.

The development of a relatively easy method for obtaining large numbers of normal, first stage true "zoeae" from detached eggs has additional interest. These zoeae, hatched in the laboratory, serve as a definite basis for the positive separation of blue crab larvae from other closely related larvae that abound in local waters. There is provided the first desirable step in an attempt to obtain successive moults leading through to the "megalops" stage. In experiments conducted during the summer of 1941, first stage zoeae moulted into the second zoeal stage characterized by six setae on each maxilliped. Further shedding failed to take place. It may be pointed out that, for the correct identification of blue crab zoeae in plankton, the importance of observing successive moults from the first true zoeal stage on up to the megalops stage cannot be over-emphasized. Thus in 1941, Dr. S. H. Hopkins at the Yorktown laboratory and Dr. E. P. Churchill working at Hampton and nearby points both report collecting from plankton tows five zoeal stages of *Callinectes sapidus*. Churchill (1941) states "there are a prezoeal and five zoeal stages." Hopkins[1] reports that one of the five zoeal stages he has found differs from any of the five found by Churchill, so it would

[1]Personal communication.

appear that altogether six zoeal stages occur. Though it is conceded that a large number of random plankton tows might lead to the collection of all the zoeal stages in this particular crab, such success is by no means a certainty since there is, as yet, no proof of the number and identity of all the zoeal stages of this crab. Positive identification of these larval stages from plankton tows is rendered more difficult because of the existence of other Portunids in and near the waters of the lower Bay. (Cowles, 1928, pp. 355-56.)

Summary

Results of laboratory and field experiments on the hatching of detached eggs of the blue crab are presented. There is described—*a*, a technic for removing sponges from the crab and for transporting them to the laboratory from the commercial crab house; *b*, a way of holding sponges for varying periods until facilities are available for hatching; *c*, a technic for removing eggs from the sponge preparatory to hatching; *d*, the technic and environmental conditions that are essential for obtaining a hatching percentage of ninety under laboratory conditions; and *e*, a preliminary experiment on a method of hatching eggs in large numbers in natural waters that offers possibilities for practical application.

Moulting of the first true zoeal stage of the blue crab to the second zoeal stage is reported for the first time.

The application of these findings to a better understanding of the early life history of the crab is defined and the importance of hatching experiments to conservation problems in Chesapeake Bay is defined and discussed.

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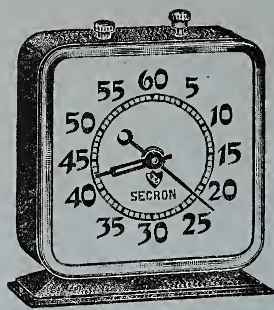
Annual Meeting of Southeastern Section of the Botanical Society of America

The third annual meeting of the Southeastern Section of the Botanical Society of America will be held on June 12, 13, and 14 at Knoxville, Tennessee, with the University of Tennessee as the host institution.

The program of the Knoxville meeting will include trips to the TVA laboratories and tree crop nursery at Norris, the Agricultural Experiment Station of The University of Tennessee and the Great Smoky Mountains National Park. A discussion of the vegetation of the Great Smoky Mountains will be lead by Dr. S. A. Cain and Dr. A. J. Sharp, of the Department of Botany, The University of Tennessee. Dr. Cain will discuss "The Tertiary Nature of Southern Appalachian Forests," while Dr. Sharp will speak on "Highlights of the Southern Appalachian Flora". An invitational lecture on "The origin and genetic structure of species; with special reference to the flora of the southeastern states," will be given by Dr. W. H. Camp, of the New York Botanical Garden.

All botanists in the Southeast are cordially invited to attend the Knoxville meeting.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